$\dot{n} = 58.173$ mol/s

*   *   *   *   *

§ 1065.644   Vacuum-decay leak rate.

This section describes how to calculate the leak rate of a vacuum-decay leak verification, which is described in § 1065.345(e). Use Eq. 1065.644–1 to calculate the leak rate, $\dot{n}_{leak}$, and compare it to the criterion specified in § 1065.345(e).

$$\dot{n}_{leak} = \frac{V_{vac}}{R} \cdot \frac{\left(\dfrac{p_2}{T_2} - \dfrac{p_1}{T_1} \right)}{(t_2 - t_1)} \quad \text{Eq. 1065.644-1}$$

Where:

V_{vac} = geometric volume of the vacuum-side of the sampling system.

R = molar gas constant.

p_2 = Vacuum-side absolute pressure at time t_2.

T_2 = Vacuum-side absolute temperature at time t_2.

p_1 = Vacuum-side absolute pressure at time t^1.

T_1 = Vacuum-side absolute temperature at time t_1.

t_2 = time at completion of vacuum-decay leak verification test.

t_1 = time at start of vacuum-decay leak verification test.

Example:

V_{vac} = 2.0000 L = 0.00200 m³
R = 8.314472 J/(mol·K)
p_2 = 50.600 kPa = 50600 Pa
T_2 = 293.15 K
p_1 = 25.300 kPa = 25300 Pa
T_1 = 293.15 K
t_2 = 10:57:35 AM
t_1 = 10:56:25 AM

$$\dot{n}_{leak} = \frac{0.0002}{8.314472} \cdot \frac{\left(\dfrac{50600}{293.15} - \dfrac{25300}{293.15} \right)}{(10:57:35 - 10:56:25)}$$

$$\dot{n}_{leak} = \frac{0.00200}{8.314472} \cdot \frac{86.304}{70}$$

$$\dot{n}_{leak} = 0.00030 \text{ mol/s}$$

[73 FR 37327, June 30, 2008]

EFFECTIVE DATE NOTE: At 73 FR 37327, June 30, 2008, § 1065.644 was added, effective July 7, 2008.

§ 1065.645   Amount of water in an ideal gas.

This section describes how to determine the amount of water in an ideal gas, which you need for various performance verifications and emission calculations. Use the equation for the vapor pressure of water in paragraph (a) of this section or another appropriate equation and, depending on whether you measure dewpoint or relative humidity, perform one of the calculations in paragraph (b) or (c) of this section.

(a) *Vapor pressure of water*. Calculate the vapor pressure of water for a given saturation temperature condition, T_{sat}, as follows, or use good engineering judgment to use a different relationship of the vapor pressure of water to a given saturation temperature condition:

(1) For humidity measurements made at ambient temperatures from (0 to 100) °C, or for humidity measurements made over super-cooled water at ambient temperatures from (−50 to 0) °C, use the following equation:

$$-\log_{10}\left(p_{H20}\right)=$$

$$10.79574\cdot\left(\frac{273.16}{T_{sat}}-1\right)+$$

$$5.02800\cdot\log_{10}\left(\frac{T_{sat}}{273.16}\right)+$$

$$1.50475\cdot10^{-4}\cdot\left(10^{-8.2969\cdot\left(\frac{T_{sat}}{273.16}\right)}-1\right)+$$

$$0.42873\cdot10^{-3}\cdot\left(1-10^{4.76955\cdot\left(1-\frac{273.16}{T_{sat}}\right)}\right)+$$

$$0.21386 \qquad \text{Eq. 1065.645-1}$$

Where:

p_{H20} = vapor pressure of water at saturation temperature condition, kPa.

T_{sat} = saturation temperature of water at measured conditions, K.

Example:

T_{sat} = 9.5 °C

T_{dsat}= 9.5 + 273.15 = 282.65 K

$$-\log_{10}\left(p_{H20}\right)=$$

$$10.79574\cdot\left(\frac{273.16}{282.65}-1\right)+$$

$$5.02800\cdot\log_{10}\left(\frac{282.65}{273.16}\right)+$$

$$1.50475\cdot10^{-4}\cdot\left(10^{-8.2969\cdot\left(\frac{282.65}{273.16}\right)}-1\right)+$$

$$0.42873\cdot10^{-3}\cdot\left(1-10^{4.76955\cdot\left(1-\frac{273.16}{282.65}\right)}\right)+$$

$$0.21386$$

$-\log_{10}(P_{H20})=-0.074297$

$p_{H20} = 10^{0.074297}$ = 1.1866 kPa

(2) For humidity measurements over ice at ambient temperatures from (−100 to 0) °C, use the following equation:

$$-\log_{10}\left(p_{sat}\right)=$$

$$9.09685\cdot\left(\frac{273.16}{T_{sat}}-1\right)+$$

$$3.56654\cdot\log_{10}\left(\frac{273.16}{T_{sat}}\right)+$$

$$0.87682\cdot\left(\frac{257.75}{T_{sat}}-1\right)+$$

$$0.21386 \qquad \text{Eq. 1065.645-2}$$

Example:

T_{ice} = − 15.4 °C

T_{ice} = − 15.4 + 273.15 = 257.75 K

$$-\log_{10}\left(p_{sat}\right)=$$

$$9.09685\cdot\left(\frac{273.16}{257.75}-1\right)+$$

$$3.56654\cdot\log_{10}\left(\frac{273.16}{257.75}\right)+$$

$$0.87682\cdot\left(\frac{257.75}{273.16}-1\right)+$$

$$0.21386$$

$-\log_{10}(p_{H20})=-0.79821$

$P_{H20} = 10^{0.074297}$ = 0.15941 kPa

(b) *Dewpoint.* If you measure humidity as a dewpoint, determine the amount of water in an ideal gas, x_{H20}, as follows:

$$x_{H2O}=\frac{p_{H2O}}{p_{abs}} \qquad \text{Eq. 1065.645-3}$$

Where:

x_{H20} = amount of water in an ideal gas.

p_{H20} = water vapor pressure at the measured dewpoint, $T_{sat}=T_{dew}$.

p_{abs} = wet static absolute pressure at the location of your dewpoint measurement.

Example:

P_{abs} = 99.980 kPa

$T_{sat}=T_{dew}$ = 9.5 °C

Using Eq. 1065.645–2,

P_{H20} = 1.1866 kPa

x_{H2O} = 1.1866/99.980

x_{H2O} = 0.011868 mol/mol

(c) *Relative humidity.* If you measure humidity as a relative humidity, *RH%,*

determine the amount of water in an ideal gas, x_{H2O}, as follows:

$$x_{H2O} = \frac{RH\% \cdot p_{H2O}}{p_{abs}} \qquad \text{Eq. 1065.645-4}$$

Where:

x_{H2O} = amount of water in an ideal gas.
$RH\%$ = relative humidity.
P_{H2O} = water vapor pressure at 100% relative humidity at the location of your relative humidity measurement, $T_{sat} = T_{amb}$.
P_{abs} = wet static absolute pressure at the location of your relative humidity measurement.

Example:

$RH\%$ = 50.77%
P_{abs} = 99.980 kPa
$T_{sat} = T_{amb}$ = 20 °C

Using Eq. 1065.645–2,

P_{H2O} = 2.3371 kPa
x_{H2O} = (50.77 · 2.3371)/99.980
x_{H2O} = 0.011868 mol/mol

EFFECTIVE DATE NOTE: At 73 FR 37327, June 30, 2008, § 1065.645 was revised, effective July 7, 2008. For the convenience of the user, the revised text is set forth as follows:

§ 1065.645 Amount of water in an ideal gas.

This section describes how to determine the amount of water in an ideal gas, which you need for various performance verifications and emission calculations. Use the equation for the vapor pressure of water in paragraph (a) of this section or another appropriate equation and, depending on whether you measure dewpoint or relative humidity, perform one of the calculations in paragraph (b) or (c) of this section.

(a) *Vapor pressure of water.* Calculate the vapor pressure of water for a given saturation temperature condition, T_{sat}, as follows, or use good engineering judgment to use a different relationship of the vapor pressure of water to a given saturation temperature condition:

(1) For humidity measurements made at ambient temperatures from (0 to 100) °C, or for humidity measurements made over super-cooled water at ambient temperatures from (-50 to 0) °C, use the following equation:

$$-\log_{10}(p_{H2O}) = 10.79574 \cdot \left(\frac{273.16}{T_{sat}} - 1\right) + 5.02800 \cdot \log_{10}\left(\frac{T_{sat}}{273.16}\right) + 1.50475 \cdot 10^{-4} \cdot \left(10^{-8.2969 \cdot \left(\frac{T_{sat}}{273.16} - 1\right)} - 1\right)$$

$$+ 0.42873 \cdot 10^{-3} \cdot \left(1 - 10^{-4.76955\left(1 - \frac{273.16}{T_{sat}}\right)}\right) + 0.21386 \qquad \text{Eq. 1065.645-1}$$

Where:

p_{H2O} = vapor pressure of water at saturation temperature condition, kPa.
T_{sat} = saturation temperature of water at measured conditions, K.

Example:

T_{sat} = 9.5 °C
T_{dsat} = 9.5 + 273.15 = 282.65 K

$$-\log_{10}(p_{H2O}) = 10.79574 \cdot \left(\frac{273.16}{282.65} - 1\right) + 5.02800 \cdot \log_{10}\left(\frac{282.65}{273.16}\right) + 1.50475 \cdot 10^{-4} \cdot \left(10^{-8.2969 \cdot \left(\frac{282.65}{273.16} - 1\right)} - 1\right)$$

$$+ 0.42873 \cdot 10^{-3} \cdot \left(1 - 10^{-4.76955\left(1 - \frac{273.16}{282.65}\right)}\right) + 0.21386$$

$-\log_{10}(p_{H2O}) = -0.073974$
$p_{H2O} = 10^{0.073974} = 1.18569$ kPa

(2) For humidity measurements over ice at ambient temperatures from (-100 to 0) °C, use the following equation: